



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

March 26, 2014

MEMORANDUM

SUBJECT: Review of "Non-Guideline Dissolution Kinetics Study" of HeiQ AGS-20

PC Code(s): 072599	DP Barcode(s)/No(s): 415003
Decision No.: 482767	Reregistration No(s). 85249-1
Petition No(s).: NA	Regulatory Action: Conditional Registration Follow-up
Risk Assess type: NA	Case No(s): 5042
TXR No.: NA	CAS No(s): 7440-22-4
MRID No(s).: 49165501	40 CFR: NA

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Background and Objective:

The study was conducted and submitted by HeiQ as required by the conditional registration granted by EPA in 2011 to their product, AGS-20. The objective of the study is to determine if AGS-20 is persistent in the environment and the extent of silver ions or nanoparticles released in water. The purpose was to determine, and characterize the rate of silver release from AGS-20 in three types of water and also to show in which fraction (i.e. ionic or particulate) the silver was released. The results will likely help to determine if AGS-20 is persistent in the aquatic environment or if it changes into different types of silver species

It is important to know the physical transformation of nanomaterials in various environmental media as this will help the EPA to understand the transformation pathways of the original particles, and at what stage these are transformed. Dissolution kinetics is one way to follow the nano behavior of various nano products. In addition, transformed nanoparticles have their own characteristics and EPA needs to understand these changed states. Open literature published studies have established that nanosilver, present in water containing dissolved oxygen, will

oxidize, and form oxidized nanoparticles partially, or form intermediates like secondary precipitates, or stay as chemically sorbed silver ions or form soluble silver ions. Some solution chemistry parameters that play key role in transformation of nanosilver particles are: pH, ionic strength, and dissolved organic carbon.

Study Type: Dissolution Kinetics
Guideline: None
Product Name: HeiQ AGS-20
Report #: HQE-A-007-2
MRID: 49203401

Testing Labs: Empa-Swiss Federal Labs for Materials Science and Technology:
Technology and Society Laboratory, Lerchenfeldstrasse 5, CH-9014 St.,
Gallen, Switzerland

And

Empa-Swiss Federal Labs for Materials Science and Technology:
Laboratory for Analytical Chemistry, Uberlandstrasse 129, CH-8600
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Sponsors: HeiQ Materials AG, Zurcherstrasse 42, 5330 Bad Zurzach/ Switzerland

GLP Compliance: The study was not conducted according to GLP requirements specified in 40CFR, Part 160.

Methodology:

The AGS-20 product was exposed to three types of water over an extended period of time, and periodically aliquots were taken out from each water sample. Each aliquot was subjected to filtration using the size fractionation method, and silver analysis was conducted to characterize the type of silver released at a given time (ionic silver, particulate silver etc.)

Test material: AGS-20 was obtained as a powder which contains 19.3 percent silver by weight.

AGS-20 was added to three types of water:

1. Distilled (DI) water. Ionic strength was adjusted by adding 1 mmol/L of sodium nitrate.
2. Simulated moderately hard water (SMHW) containing: Calcium sulfate*2 H₂O: 67 ppm; magnesium sulfate: 60 ppm; sodium bicarbonate: 96.6 ppm; and potassium chloride: 4 ppm. The pH of the SMHW was 7.46.
3. River water: Obtained from Sitter River in St. Gallen. The pH of this water is 8.0. It was filtered through 0.45 micrometer filter. No other physical/chemical parameters of this water were included in the report.

Multiday Dissolution Procedure

1. 50.0 mg of AGS-20, which contains 19.3 percent silver, was dissolved in 50 ml distilled water to produce a stock solution of 193 ppm silver.
2. The stock solution (1.295 ml) was added to 500 ml samples of the three water types (DI, SMHW and river) to yield a silver concentration of 500 ug/liter. This was done in brown polyethylene (PE) bottles that had been pre washed with 2ml/L of nitric acid. There were three replicates prepared for each of the three water types (DI, SMHW, River) for a total of nine samples.
3. The sample bottles containing AGS-20 were shaken continuously at 150 revolutions per minute.
4. Aliquots from the sample bottles were collected at: 0 h, 8h, 1d, 2d, 5d, 9d, 19d, 40d for filtration and analysis. The silver content of the samples from day 9 and day 19 were measured directly using Ion Selective Electrode (ISE).

Single Day Kinetics of Dissolution Procedure

The kinetics of dissolution was examined using ISE during an eight hour period using three additional samples (one of each type of water). Samples were analyzed directly before addition of AGS-20, after 1 minute, 2 min., 5 min., 10 min., 15 min., 30 min, 1 hour, 2 hour, 5 hour and 8 hour. All samples were constantly stirred and the pH was measured before and after the 8 hour test period.

Filtration and Analysis Methods

This study used a fractionation by filtration method that was adopted from an open literature study (Lorenz, 2012). Fractionation by filtration is a technique used by many nanotechnology researchers to separate and differentiate between various types of species (ions, nano-sized, and aggregates) present in aqueous medium. This study used 0.45 micron filters, 0.1 micron filters and 10kDa filter membranes. It was anticipated that dissolved or ionic silver would pass through 10kDa filter membranes, silver of nanosized particulates would pass through the 0.1micron filter, and silver of larger size particulates would pass through the 0.45 micron filter.

The analysis of the filtrate samples was done using Inductively Coupled Plasma –Mass Spectrometry (ICP-MS). This method is very sensitive and can provide results in the nanogram per liter range for silver. Thus, since the solutions or filtrates in the present work were in the range of 0.05 to 0.1 microgram per liter ranges, the analysis by ICP-MS is quite reliable.

Quality Control Samples

Three types of quality control samples were processed:

1. Positive control with Ag^+ : A 100 ppt silver ion solution was made by adding AgNO_3 and filtered through the filtration systems: 0.45 micrometer filters, 0.1 micrometer filters, and 10 kDa filters.
2. Recovery of silver in the filtrates. 20 microliters of standard silver was added to 200 ml of each type of water; free silver was analyzed by ISE before the filtration and after the filtration through three filter types indicated above.
3. Silver background: Samples of the three water types that were not treated with AGS-20 were filtered through the same filter types and filtrates analyzed by ICP-MS technique.

Calibration curves

For each water type, a calibration curve was generated. For ISE method a separate calibration curve was generated.

Recoveries

Ag recovery in DI water was the best of the three (36%); recovery in MHRW was the lowest of the three (10%). Thus recovery rates: DI > river water > MHRW.

Silver speciation

Silver speciation was calculated through VisualMINTQ software. Due to problems with dissolved organic carbon (DOC) calculations, the complexation of silver with DOC analysis was low.

Interpretations on Size Fractionation of dissolved silver from AGS-20:

The dissolution rate in DI water increased rapidly for the first few hours to 100 parts per trillion (ppt) and attained a steady state of 180 ppt in 9 days. This translates to 36% of the total silver present. All three filter systems showed similar results.

The dissolution rate in MHRW reached 100 ppt in one day and decreased to 60 ppt by day 19. All three filter systems behaved similarly.

The maximum dissolution rate in river water after one day was 70 ppt and constantly decreased to 30 ppt. Initially the 0.45 micron filters behaved differently from the other two filters, and then after a few days the differences in the filtration rates disappeared.

Summary of Study Results

- AGS-20 dissolved more in DI water than in river water and MHRW. Even in DI water only 36% dissolution is observed.
- Oxygen is present in water and may also have been added incidentally when the water containers are opened for aliquot removal. Some factors influencing the results are: Excess oxygen enters into the AGS-20 matrix, silver ion extraction from the silica matrix, dissolution of silver, and in river water, as well in the MHRW, presence of other ions, as well as DOC could be adding to little known interactions between oxygen/silver/AGS-20, and within AGS-20 presence of silica may introduce another complication.
- The pH drop in DI water (from 5.7 to 2.8) perhaps facilitated the breakup of AGS-20 silica-Ag bonds, thus increasing the dissolution of silver ions in DI. The extent of dissolution is less in river water and MHRW due to the presence of a variety of ions, including complex ions or molecules
- No particulate smaller than 450 nm was detected. River water samples indicated the presence of a small amount of particles between 100 nm to 450 nm.
- In MHRW and river water a loss of silver was indicated. This could be due to sticking of silver (along with other materials) on the walls; formation of larger than 450 nm size particulates and speciation of silver into silver chloride and other chlorides of silver. Thus precipitation processes may be complicating the observed silver calculations in the aqueous medium.
- The concentrations of silver measured by ISE and ICP-MS were similar to each other. Thus the two techniques were complementary to each other and can be regarded as validation techniques.

Limitations of the Study

Although the samples are generated within 30 seconds to a minute after the mixing of AGS-20 into the water samples, the analysis of each sample aliquot is time consuming when using techniques like ICP MS. Therefore it is possible that any nano silver that was released may have converted into silver ions or conventional size particles of elemental silver during the analysis.

Except in DI water results, the data and results are mired in difficulties to unambiguously analyze and interpret results in river water and MHRW.

The study results appear to be acceptable for short durations (8 hours,). How many and kind of changes in silver species that may take place over longer periods (i.e. 6 months to a year) in river water and MHRW are not known.

Conclusion

Despite the above mentioned limitations, the study suggests that up to 36 percent of the silver content of AGS-20 is released by dissolution depending upon the water type. The study also suggests that this dissolution did not result in the release of nanoparticles of silver.

The study is classified as **supplemental**.